Observation of ^{24}Na Decays in the SNO Detector During the Salt Injection

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The Sudbury Neutrino Observatory will operate in the three phases with different methods of detecting the free neutrons produced by the Neutral-Current interactions of solar neutrinos with heavy water. In the first phase the central 6-m radius spherical region enclosed by the acrylic vessel was filled with pure D_2O, with most of the neutrons escaping to the acrylic vessel and capturing on H and only 30% capturing on D. In the second phase, which began in May 2001, 2 tons of pure NaCl was added to the heavy water, so that most of the neutrons capture on Cl, producing a 8.6 MeV gamma ray cascade.

One of the difficulties of using NaCl as the additive is the production of ^{24}Na by neutron capture on ^{23}Na. This decay, with a lifetime of 21.6 hours, normally produces coincident 2.75 MeV and 1.36 MeV gamma rays. While in the underground storage tanks, the neutron and high-energy gamma fluxes from the walls will produce ^{24}Na in the brine. However, after the brine is injected into the detector, it will be shielded from the neutron and gamma backgrounds and the ^{24}Na should decay away. The 2.75 MeV gamma rays can be problematic since they are energetic enough to photodisintegrate deuterium, producing backgrounds to the solar neutrino signal. Following the salt injection it was necessary to wait until the background levels returned to their pre-injection levels to before using the data for solar neutrino analysis.

A low energy cut window based on the reconstructed position, number of phototube hits, isotropy parameter, and reconstructed direction of the events was used to obtain a sample rich in ^{24}Na events. The events in this sample are plotted as a function of time since the salt injection in Figure 1. Notice that there appears to be a slight increase in the activity following the conversion of the level switches, which we might expect due to radon leaking into the detector at that time. However, it appears to largely decay away prior to the salt injection. During the 110-hour salt injection, the number of events ramps

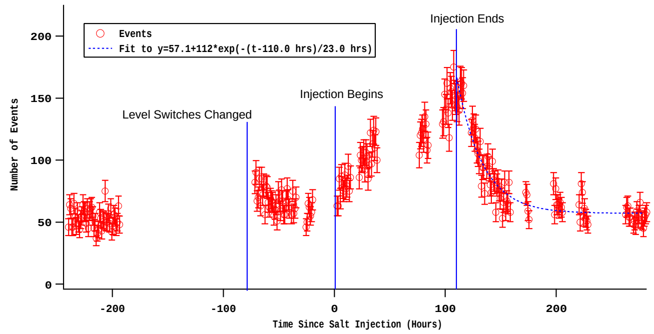

Figure 1: This plot shows the events in the ^{24}Na cut window as a function of the time since the beginning of salt injection.

up. Following the injection of salt, the number of events decays away exponentially. The points after the end of the injection were fit to an exponential, yielding value of 57.1±2 events for the background and 23.0±1.9 hours for the lifetime. The lifetime obtained by the fit is also in agreement with the 21.6 hour lifetime of ^{24}Na. We can also perform a fit to flat background for the runs taken before the salt injection. The fit to the data from runs from before the conversion of the level switches yields a value of 52.8±1.1. Thus the background after the salt injection is consistent with the background before the salt injection at the 10% level. Therefore, the temporal distribution of the events indicates that significant backgrounds were not added to the detector with the salt injection and the observed low-energy Cherenkov signal during this time is consistent with ^{24}Na events.

References

[1] Marino, Alysia D., “A Study of ^{24}NaDecays in the SNO Detector Following Salt Addition”, SNO-STR-2001-006

[2] Marino, Alysia D., ”Observation of ^{24}Na Decays in the SNO Detector During the Salt Injection”, SNO-STR-2001-015